TACCIMO
Template for Assessing Climate Change Impacts and Management Options

TACCIMO Literature Report

Literature Report – Annotated Bibliography Format
Report Date: May 17, 2013

Content Selections:
FACTORS – Invasive Species
CATEGORIES – Invasive Animals: Aquatic, Invasive Plants: Aquatic and Riparian
REGIONS – National, East, R9: Eastern, North Atlantic, North Central, R8: Southern, South Atlantic, South Central

How to cite the information contained within this report

Each source found within the TACICMO literature report should be cited individually. APA 6th edition formatted citations are given for each source. The use of TACCIMO may be recognized using the following acknowledgement:

"*We acknowledge the Template for Assessing Climate Change Impacts and Management Options (TACCIMO) for its role in making available their database of climate change science. Support of this database is provided by the Eastern Forest Environmental Threat Assessment Center, USDA Forest Service.*"

Best available scientific information justification

Content in this Literature report is based on peer reviewed literature available and reviewed as of the date of this report. The inclusion of information in TACCIMO is performed following documented methods and criteria designed to ensure scientific credibility. This information reflects a comprehensive literature review process concentrating on focal resources within the geographic areas of interest.

Suggested next steps

TACCIMO provides information to support the initial phase of a more comprehensive and rigorous evaluation of climate change within a broader science assessment and decision support framework. Possible next steps include:

1. Highlighting key sources and excerpts
2. Reviewing primary sources where needed
3. Consulting with local experts
4. Summarizing excerpts within a broader context

More information can be found in the user guide. The section entitled Content Guidance provides a detailed explanation of the purpose, strengths, limitations, and intended applications of the provided information.

Where this document goes

The TACCIMO literature report may be appropriate as an appendix to the main document or may simply be included in the administrative record.

Brief content methods

Content in the Literature Reports is the product of a rigorous literature review process focused on cataloguing sources describing the effects of climate change on natural resources and adaptive management options to use in the face of climate change. Excerpts are selected from the body of the source papers to capture key points, focusing on the results and discussions sections and those results that are most pertinent to land managers and natural resource planners. Both primary effects (e.g., increasing temperatures and changing precipitation patterns) and secondary effects (e.g., impacts of high temperatures on biological communities) are considered. Guidelines and other background information are documented in the user guide. The section entitled Content Production System fully explains methods and criteria for the inclusion of content in TACCIMO.

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Effects by Source

Friday, May 17, 2013

RESOURCE AREA (FACTOR): INVASIVE SPECIES

INVASIVE ANIMALS: AQUATIC

NATIONAL

Brown, J. H., & Sax, D. F. (2004). An essay on some topics concerning invasive species. Austral Ecology, 530-536.

"For another, extinctions of many native species cannot be attributed solely to invading aliens. The exotics may have played a role, but other human impacts, such as habitat destruction and fragmentation also contributed. For example, Gido and Brown (1999) reported that invading exotic fishes increased net species richness in 100 of 124 watersheds in temperate North America. Species richness decreased in 20 of the 24 remaining watersheds, but dams, water diversion, and pollution almost certainly contributed to these extinctions."

Rahel, F. J., Bierwagen, B., & Taniguchi, Y. (2008). Managing aquatic species of conservation concern in the face of climate change and invasive species. Conservation Biology, 22(3), 551-561.

"An example of an invasive species predicted to expand its distribution with climate change is the common carp (Cyprinus carpio). Across the United States, the number of stream sites with suitable thermal conditions for common carp is predicted to increase by 33% (Mohseni et al. 2003). This increase reflects both the northward expansion of streams with suitable thermal conditions and expansion of the species into higher elevation sites in the Rocky Mountains."

"In general the amount of food consumed by fish and other aquatic ectotherms increases with temperature until it declines sharply just before lethal temperatures are reached. At high latitudes or elevations, cold water temperatures limit food consumption by these species for much of the year. Climate warming will allow food consumption to increase and thus could exacerbate the effects of invasive, predatory species on native prey species."

Rahel, F. J., & Olden, J. D. (2008). Assessing the Effects of Climate Change on Aquatic Invasive Species. Conservation Biology, 22(3), 521–533. doi: 10.1111/j.1523-1739.2008.00950.x

"Many fishes raised in outdoor facilities for the aquarium trade are tropical species. With climate warming, their culture can expand northward. Water gardens, which are often stocked with non-native species, also could become more widespread as winters become milder (Maki & Galatowitsch 2004). Unfortunately, aquatic organisms often escape captive-breeding facilities and become invasive (e.g., bighead carp [Hypophthalmichthys nobilis], walking catfish [Clarias batrachus], American bullfrog [Rana catesbeiana]; Fuller et al. 1999; Orchard 1999; Padilla & Williams 2004, respectively). Climate warming will therefore likely increase the pool of invasive species by facilitating the spread of fish-culture facilities and water gardens to new areas."

"Mohseni et al. (2003) predict that the number of stream stations with suitable thermal habitat for warmwater fishes will increase by 31% across the coterminous United States. Sharma et al. (2007)

estimate the distribution of smallmouth bass (Micropterus dolomieu) in Canada will advance northward to encompass much of the country by the year 2100, and a similar scenario is envisioned for the highly invasive common carp (Cyprinus carpio) (Minns & Moore 1995)."

"Establishment of tropical species within the coterminous United States has generally been limited to southern states, but releases of tropical species into open waterways have been recorded throughout North America (Fuller et al. 1999). For example, piranha (Pygocentrus or Serrasalmus) have been recorded in 22 states, and although no populations have become established, areas where overwinter survival is possible may increase with climate warming (Fig. 4)."

"Climate warming will reduce the extent of ice cover and thus lessen the occurrence of winter hypoxia (Stefan et al. 2001). This could allow colonization of these lakes by piscivorous fish, such as bass (Micropterus spp.), that would, in turn, cause local extirpation of populations of small-bodied fishes (Jackson & Mandrak 2002) and amphibians (Kats & Ferrer 2003)."

"An increase in floods may increase the dispersal of non-native species, such as zebra mussels, whose planktonic larvae are transported through streams (Havel et al. 2005)."

"Reservoirs may also influence biotic interactions between native and non-native species. Non-native species may be minor components of the biota in streams but can become competitively dominant species in reservoirs (e.g., common carp and zebra mussels; Havel et al. 2005)."

NORTH CENTRAL

Rahel, F. J., Bierwagen, B., & Taniguchi, Y. (2008). Managing aquatic species of conservation concern in the face of climate change and invasive species. Conservation Biology, 22(3), 551-561.

" In the Laurentian Great Lakes basin warmer temperatures, especially in winter, are expected to favor expansion of invasive species, including alewife (Alosa pseudoharengus), round goby (Neogobius melanostomus), Eurasian ruffe (Gymnocephalus cernuus), and sea lamprey (Petromyzonmarinus) (Holmes 1990; Bronte et al. 2003). These invasions would be detrimental to native species such as yellow perch (Perca flavescens) and lake trout (S. namaycush)."

R8: SOUTHERN

Byers, J. E., McDowell, W. G., Dodd, S. R., Haynie, R. S., Pintor, L. M., & Wilde, S. B. (2013). Climate and pH Predict the Potential Range of the Invasive Apple Snail (Pomacea insularum) in the Southeastern United States. PloS one, 8(2), e56812.

"Pomacea insularum [the invasive apple snail] has spread rapidly in the southeastern USA only during the last decade. Our maximum entropy model [using distribution data from the USGS Nonindigenous Aquatic Species database] indicates that the coastal plain from Texas to South Carolina is at high risk for P. insularum invasion based on climate suitability. The coastal plain of North Carolina appears less at risk because of both borderline climate conditions and widespread low pH (Figure 4)."

"Our results [using a maximum entropy model with distribution data from the USGS Nonindigenous Aquatic Species database] indicate that the minimum temperature in the coldest months and maximum amount of precipitation in the warmest months are the best predictors [of habitat for the invasive apple snail, Pomacea insularum] of the nineteen variables included in the BioClim database. For shallow or smaller water bodies, these climatic variables equate to warmer overwintering temperatures and more permanent aquatic habitat (i.e. reduced chance of desiccation). These abiotic variables should directly reflect the likelihood of surviving freezing and desiccation. However, they may interact with important

biological variables, like predation, which should also affect invasion success."

Drake, J. M., & Bossenbroek, J. M. (2004). The potential distribution of zebra mussels in the United States. BioScience, 54(10), 931-941. doi:10.1641/00063568(2004)054[0931:TPDOZM]2.0.CO;2

"Turning to our projections of invasion risk in the Southeast [using a genetic algorithm for rule-set production (GARP) that includes the IPCC (Intergovernmental Panel on Climate Change) baseline climate dataset to select predictive models of species ranges], where the species richness of unionid mussels is especially high (figure 7), we observe that this region is highly susceptible to zebra mussel [Dreissena polymorpha] invasion, according to model I (with the risk of invasion approaching 100 percent). In the Southeast, unlike the western river systems, models II and III show a significantly lower invasion risk than model I, diminishing our confidence that the region is habitable by zebra mussels. However, this only reduces the risk from high (approaching 100 percent) to moderate (about 50 percent). Given the high density of endemic unionid species, even the lowest estimates of invasion risk in the Southeast are worrisome. We reiterate that even if our models suggest that a region is habitable by zebra mussels in only 50 of 100 models, this is unacceptably high in light of the high biodiversity losses to be expected from invasion by zebra mussels."

R9: EASTERN

Rahel, F. J., & Olden, J. D. (2008). Assessing the Effects of Climate Change on Aquatic Invasive Species. Conservation Biology, 22(3), 521–533. doi: 10.1111/j.1523-1739.2008.00950.x

"Mandrak (1989) predicts that with climate warming, 19 warmwater fish species from the Mississippi or Atlantic Coastal basins may invade the lower Laurentian Great Lakes (Ontario, Erie, and Michigan) and that 8 warmwater fish species currently present in the lower Great Lakes could invade the upper Great Lakes (Huron and Superior). These 27 fish species would bring with them 83 species of parasites that do not currently exist in the Great Lakes, opening the door for epizootic outbreaks of pathogens in immunologically na¨ıve native fishes (Marcogliese 2001)."

SOUTH ATLANTIC

Firth, L. B., Knights, A. M., & Bell, S. S. (2011). Air temperature and winter mortality: Implications for the persistence of the invasive mussel, Perna viridis in the intertidal zone of the south-eastern United States. Journal of Experimental Marine Biology and Ecology, 400(1), 250-256. doi:10.1016/j.jembe.2011.02.007

"Furthermore [in addition to the lack of information on the effects of cool thermal stress], despite many intertidal organisms being exposed to aerial conditions during low water, less attention has been directed at assessing the effects of extreme air temperatures in comparison to extreme water temperatures. This focus is perhaps surprising as larger fluctuations in temperature are more likely to occur in aerial environments than aquatic environments due to the buffering capacity of water (Marshall and Plumb, 2008). In a subtropical setting such as described here [studying the invasive green mussel (Perna viridis) in Tampa Bay, Florida], low aerial temperatures may be an important mechanism by which mussels are prevented from excluding other fouling organisms, such as oysters and barnacles."

"Two of the predictions accompanying discussions of global climate change are (1) a rise in the mean sea surface temperature globally and (2) an increase in the occurrence, intensity and magnitude of extreme weather events (IPCC, 2007). Stachowicz et al. (2002) proposed that changing maximum and minimum temperatures rather than shifts in annual means could account for the greatest impacts of climate change on marine communities. Our findings on the [invasive] green mussel [Perna viridis] [showing die back

events with low water temperatures in Tampa Bay, Florida] provide support for this proposal. Future studies on changes in community assemblages that follow assemblages across years both with and without extreme weather events are necessary."

"The results of the present study [surveying mussels following unusually cold weather events in Tampa Bay, Florida] suggest that physiological stress driven by extreme weather may be responsible for limiting the invasion success of the green mussel [Perna viridis] in a subtropical area."

Harrison, J. R., & Knott, D. M. (2007). Occurrence of Microtralia ovula and Creedonia succinea (Gastropoda: Pulmonata: Ellobiidae) in South Carolina. Southeastern Naturalist, 6(1), 173-178. doi:10.1656/1528-7092(2007)6[173:OOMOAC]2.0.CO;2

"The new records [from the collections of the Southeastern Regional Taxonomic Center in Charleston, SC] of Creedonia succinea and Microtralia ovula [non-native ellobiid snails] presented here provide evidence that the two species are now established in South Carolina waters. Further collecting within their newly extended range should reveal their occurrence in additional localities. Similar northward expansion of the ranges of the anomuran decapod Petrolisthes armatus (Gibbes, 1850) and the amphipod Caprella scaura Templeton, both from south Florida and northwestern Atlantic tropical waters into South Carolina, have recently been documented (Foster et al. 2004, Knott et al. 2000). These observations conform to the speculation of Engle and Summers (1999) that distributional shifts of estuarine benthic fauna are likely to occur along the Atlantic coast, given current climate-change scenarios that predict increased global temperatures of up to 2 °C. It is also likely that the ranges of some species will be extended into South Carolina simply as a result of increased scrutiny of the biodiversity of that region. "

Rahel, F. J., & Olden, J. D. (2008). Assessing the Effects of Climate Change on Aquatic Invasive Species. Conservation Biology, 22(3), 521–533. doi: 10.1111/j.1523-1739.2008.00950.x

"In freshwater systems climate change is associated with earlier breeding in amphibians (Beebee 1995), earlier emergence of dragonflies (Odonata) (Hassall et al. 2007), and compositional shifts of entire insect communities (Burgmer et al. 2007). There is speculation that the recent establishment of 2 species of tropical dragonflies in Florida represents a natural invasion from Cuba and the Bahamas that is related to climate change (Paulson 2001)."

INVASIVE PLANTS: AQUATIC & RIPARIAN

NATIONAL

Chen, D. X., Coughenour, M. B., Eberts, D., & Thullen, J. S. (1994). Interactive effects of CO2 enrichment and temperature on the growth of dioecious Hydrilla verticillata. Environmental and Experimental Botany, 34(4), 345-353.

"Elevated atmospheric CO2 concentration enhanced the growth of [invasive] Hydrilla (Hydrilla verticillata) plants [in a greenhouse experiment], while the percentage of the enhancement is strongly temperature dependent in these experiments. The maximum relative effects of CO2 enrichment was at 25°C. The total dry matter production was increased about 27% by doubling CO2 at 15°C, and increased about 46% at 25°C. However, at 32°C, the percentage of the enhancement was only about 7%."

Hellmann, J. J., Byers, J. E., Bierwagen, B. G., & Dukes, J. S. (2008). Five potential consequences of climate change for invasive species. Conservation Biology, 22(3), 534-543.

"Warmer conditions are of particular concern in temperate regions because many invasive species have range limits set by extreme cold temperatures or ice cover (Grodowitz et al. 1991; Owens & Madsen 1995; Ayres & Lombardero 2000; Owens et al. 2004). Managers in the northeastern United States are concerned that aquatic invasive species such as hydrilla (Hydrilla verticillata) and water hyacinth (Eichhornia crassipes) will be able to overwinter if temperatures increase, snowfall is reduced, the frequency of freeze–thaw cycles increase or seasonal ice cover melts earlier in the year (Hayhoe et al. 2007; U.S. EPA 2008). Milder winters would not only increase survival but also create longer growing seasons, potentially increasing reproductive output."

"Climate change also may alter the effectiveness of biocontrol. Successful biocontrol agents are highly specific to the invasive species they are targeted to control, and changes in climatic factors may alter these interspecific interactions (Bryant et al. 2002; Stireman et al. 2005; van Asch & Visser 2007). Taxa currently controlled by a predator or herbivore, therefore, may reemerge as problem species. For example, managers in Colorado are concerned that the saltcedar leaf beetle (Diorhabda elongata) will stop being effective at controlling Tamarisk (Tamarix ramosissima) if air temperatures increase (U.S. EPA 2008)."

Rahel, F. J., Bierwagen, B., & Taniguchi, Y. (2008). Managing aquatic species of conservation concern in the face of climate change and invasive species. Conservation Biology, 22(3), 551-561.

"Low light conditions under the ice can limit the occurrence of aquatic plants, and therefore a reduction in ice cover could allow colonization by new species. The recent invasion by threadleaf water-crowfoot (Ranunculus trichophyllus) into several high-elevation lakes in the Himalayas has been attributed to a decrease in the length of ice cover due to climate warming (Lacoul & Freedman 2006)."

Rahel, F. J., & Olden, J. D. (2008). Assessing the Effects of Climate Change on Aquatic Invasive Species. Conservation Biology, 22(3), 521–533. doi: 10.1111/j.1523-1739.2008.00950.x

"Climate change will reduce the extent of ice cover on lakes in the northern hemisphere (Magnuson et al. 2000), which may influence the invasion process by increasing light levels for aquatic plants, reducing the occurrence of low oxygen conditions in winter, and exposing aquatic organisms to longer periods of predation from terrestrial predators."

"Elevated salinity in floodplains may favor the ongoing invasion and impact of salt cedar [Tamarix spp.], and current efforts to eliminate it and reestablish native riparian species by flooding areas below dams may need to account for salt deposits in riparian soils."

Villamagna, A. M., & Murphy, B. R. (2010). Ecological and socio-economic impacts of invasive water hyacinth (Eichhornia crassipes): a review. Freshwater Biology, 55(2), 282-298. doi:10.1111/j.1365-2427.2009.02294.x

"Water hyacinth [Eichhornia crassipes] has invaded freshwater systems in over 50 countries on five continents and, according to recent climate change models, its distribution may expand into higher latitudes as temperatures rise (Rodríguez-Gallego et al., 2004; Hellmann et al., 2008; Rahel & Olden, 2008)."

R8: SOUTHERN

Hellmann, J. J., Byers, J. E., Bierwagen, B. G., & Dukes, J. S. (2008). Five potential consequences of climate change for invasive species. Conservation Biology, 22(3), 534-543.

"Conversely, climate change may increase the effectiveness of biocontrol agents in some locations. For example, one of the most effective biological control agents for alligator weed (Alternanthera philoxeroides) in the southeastern United States is the alligator weed flea beetle (Agasicles hygrophila). Climatic tolerances for the beetle and plant do not match exactly, and the beetle is only effective in the warmer part of the invasive plant's distribution (Julien et al. 1995; Stewart et al. 1999). Warmer temperatures could allow this biocontrol agent to become effective in a larger part of the invasive species' range (Hruska et al. 1985). Unfortunately, these warming trends are likely to also allow alligator weed to spread northward. Future biocontrol attempts must consider climate variables in evaluating long-term effectiveness (Zalucki & van Klinken 2006)."

Pattison, R. R., & Mack, R. N. (2008). Potential distribution of the invasive tree triadica sebifera (euphorbiaceae) in the united states: Evaluating climex predictions with field trials. Global Change Biology, 813-826.

"The likelihood of this spread is heightened by factoring in the tree's [Triadica sibifera] occurrence near perennial sources of water because the potential unoccupied range of T. sebifera includes some of the most dissected watersheds in the USA (Thornbury, 1965). Within major watersheds, such as those of the Tennessee and Cumberland Rivers, T. sebifera could spread extensively."

SOUTH ATLANTIC

Mulholland, P. J., Best, G. R., Coutant, C. C., Hornberger, G. M., Meyer, J. L., Robinson, P. J, Stenberg, J. R., … & Wetzel, R. G. (1997). Effects of climate change on freshwater ecosystems of the south-eastern United States and the Gulf Coast of Mexico. Hydrological Processes, 11, 949-970. doi: 10.1002/(SICI)1099-1085(19970630)11:8<949::AID-HYP513>3.0.CO;2-G

"Increasing winter minimum temperatures (or more probably reduction in the frequency and severity of freezing conditions) will most likely produce a northward shift in the range of subtropical species [in Florida]. Range shifts would be expected for several recently introduced invasive species, such as the tree Melaleuca quinquenervia (Cajeput) and the shrub Schinus terebinthifolius (Brazilian pepper), that can quickly suppress native species. In central and northern portions of the state, freshwater marshes may become dominated by Melaleuca and hardwood swamps by Schinus, as has occurred in the south."

Pattison, R. R., & Mack, R. N. (2009). Environmental constraints on the invasion of Triadica sebifera in the eastern United States: an experimental field assessment. Oecologia, 158(4), 591-602. doi: 10.1007/s00442-008-1187-7

"These field trials [using seeds collected from approx. 50 trees near Georgetown, SC, USA] provide evidence for the likely spread of Chinese tallow tree [Triadica sebifera] to 38°N latitude and inland along the Savannah River."

"We had earlier found evidence for potential northward and inland spread for this invader [Chinese tallow tree, Triadica sebifera], based on projections from the CLIMEX model (Pattison and Mack 2008). Our field results [using seeds collected from approx. 50 trees near Georgetown, SC, USA] largely reinforce those predictions as well as provide insight into the tree's response to different microhabitats. Spread of T. sebifera, based on both lines of evidence, appears far from complete in the United States. But the extent to which on-going global atmospheric change will influence this range occupation complicates any predictions (Pattison and Mack 2008)."

EAST

Chambers, R. M., Osgood, D. T., Bart, D. J., & Montalto, F. (2003). Phragmites australis invasion and expansion in tidal wetlands: interactions among salinity, sulfide, and hydrology. Estuaries, 26(2), 398-406.

"Longer-term, chronic changes in flooding are driven by relative sea level rise. In individual marshes, rising sea level may increase wetland hydroperiod and confer resistance to Phragmites invasion by seeds or rhizome fragments. With sea level rise, however, the local groundwater table adjacent to tidal wetlands is raised, and surface water runoff increases relative to groundwater inputs to marshes (Nuttle and Portnoy 1992). A 10-cm rise in sea level is predicted to increase surface water runoff to a coastal Massachusetts marsh by 70%. Also, with the upland groundwater table closer to soil surfaces, a potentially larger upland fringe is susceptible to Phragmites establishment during periods of sea level rise."

Hellmann, J. J., Byers, J. E., Bierwagen, B. G., & Dukes, J. S. (2008). Five potential consequences of climate change for invasive species. Conservation Biology, 22(3), 534-543.

"In contrast [to climate change reducing the utility of restoration projects], sea-level rise may be an example of how managers can use climate change for their benefit, at least in the short term. Restoration of tidal flows in coastal wetlands is one strategy that may effectively control Phragmites australis and purple loosestrife (Lythrum salicaria), particularly for wetlands along the U.S. Atlantic coast that were previously dominated by smooth cordgrass (Spartina alterniflora) (Chambers et al. 2002; Konisky & Burdick 2004; Vasquez et al. 2006). Managers of invasive species in Connecticut use this restoration technique to control these invasive plants in areas where native vegetation is more salt tolerant (U.S. EPA 2008). Detailed maps of estimated sea-level rise and distributions of Spartina-dominated salt marshes would inform where tidal management could be used effectively."